

A coincidence scintillation spectrometer

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With 4 figures in the text

A scintillation counter offers several advantages: high γ -efficiency, fast pulses, short recovery time, and proportionality. These properties make the counter suitable for coincidence work. This is a preliminary report on attempts to exploit the scintillation counter as a γ -proportional device in coincidence.

Main features

The working principles of the apparatus may be seen through the examination of Fig. 1. Signals from the photo-multipliers are linearly amplified. The resulting pulses from the first channel are fed into the coincidence circuit and also through the delay-line to the gate. Pulses from the second channel are discriminated before entrance into the coincidence circuit. The coincidence pulse opens the gate to let the delayed pulse from the first counter pass into the ten-channel pulse analyzer, where the spectrum of the coinciding pulses is obtained. This arrangement facilitates the use of a fast coincidence stage and a slow, inexpensive multi-channel analyzer. When analyzing the direct pulse spectrum from the first counter, the second counter is replaced by a thyratron oscillator. Its frequency can be varied to give a suitable rate of chance coincidences. This procedure makes it possible to investigate the original pulse distribution without changing the source strength or the geometry of the experimental set-up.

Electronic devices

The linear amplifiers are type A 1 (1). Cathode followers are sufficient as preamplifiers. The rise time is 0.15 μ sec. When discriminating is necessary, the built-in pulse height selector is used.

Before the coincidence stage the pulses are shaped in blocking oscillators. The mixer is a 6AS6 pentode. By varying the working conditions of the mixer tube and the output discrimination the time resolution is easily varied between 0.08 and 0.5 μ sec. A resolving time of 0.3 μ sec. gives coincidence losses of only a few percent.

The coincidence pulse triggers a fast electron-coupled univibrator which produces a 4 μ sec. negative gating pulse. The gate is a double 6AG7 clamp. The pulse to be measured passes through a 1.7 μ sec. lumped delay-line to enter the gate in proper time. The pedestals are removed in a difference amplifier.

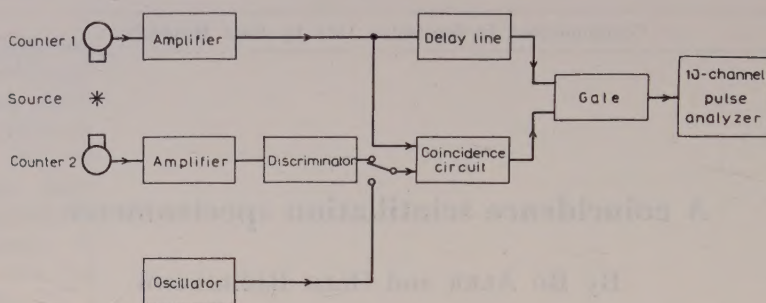


Fig. 1. Block scheme of the coincidence scintillation spectrometer.

The signals are then amplified to obtain a suitable negative pulse for the ten-channel pulse analyzer. This is a slightly modified analyzer of the type constructed by Guy von Dardel (2).

γ -pulse spectra from different counters

Hitherto only organic scintillators have been used because of their fast scintillation decay time. The crystals are made by cooling down a melt very slowly (3). They are cylindrical, clear, and have only a few cracks. The diameter is 30 mm and the heights range up to 35 mm.

The first attempts to use the proportionality in coincidence were made with scintillation counters which originally were designed for high efficiency γ -counting. They consist of a 20–30 mm anthracene scintillator in front of a RCA 1P21 photo-multiplier. The crystal is backed with a thin aluminium foil but no spe-

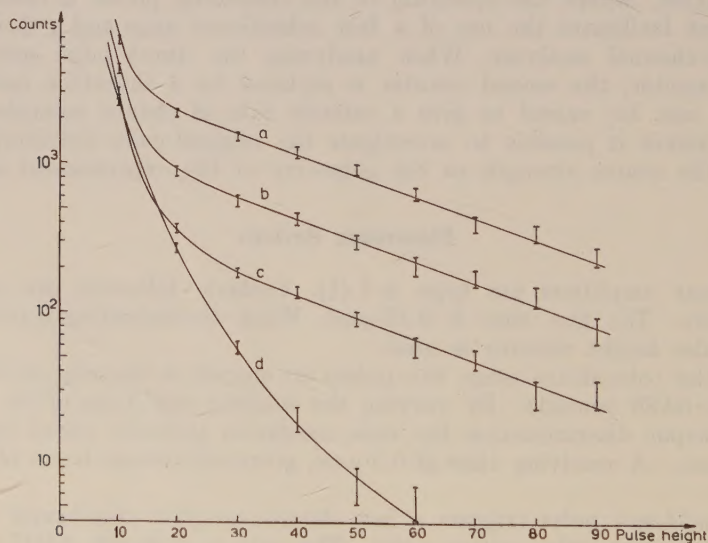


Fig. 2. γ -pulse spectra, 26 mm anthracene and 1P21. *a*: Co^{60} , original. *b*: Co^{60} , coincidence. *c*: Na^{22} , original. *d*: Na^{22} , annihilation quanta only.

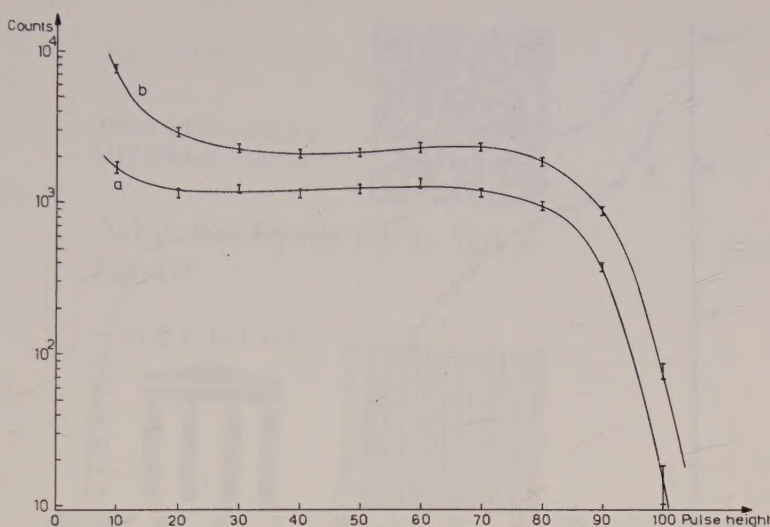


Fig. 3. Co^{60} γ -pulse spectra, 12 mm stilbene and E.M.I. 5311. *a*: original. *b*: coincidence.

cial arrangements are made for the optical fitting of the crystal to the multiplier glass-wall. The counter is held at constant temperature by water cooling.

Fig. 2. shows the distributions from Co^{60} γ -rays directly and in coincidence, obtained with a 26 mm anthracene scintillator. The number of pulses within a given amplitude interval is plotted against the pulse height. Distributions from a Na^{22} source covered with sufficient absorber to stop the positrons are seen in the same figure. One curve shows the direct pulse distribution containing pulses from annihilation quanta and the following 1.3 MeV γ -ray. The other curve shows the spectrum from excess coincidences in 180° position, i.e. only pulses from annihilation quanta. When discriminating the pulses from the second counter in order to let through only pulses originating from 1.3 MeV quanta the same 0.5 MeV distribution was obtained in 135° position. All curves are corrected for background and chance coincidences.

The large size and defects of the crystal and particularly the poor cathode geometry causes a considerable broadening of the Compton distribution. It is only possible to distinguish between γ -rays with great and appreciably different energies. For γ -energies below the 0.5 MeV region this crystal size rapidly approaches a "semi-thick" case (4) why no pure Compton distributions are to be expected.

To increase the energy resolution of scintillation counters with organic scintillators it is necessary to use a photo-multiplier with a larger cathode area than that of the 1P21 type. The RCA multiplier 5819 is not yet available in this country. Experiments were recently started with the E. M. I. 5311 multiplier photo tube (5). Curves obtained with a 12 mm stilbene crystal are shown in Figures 3 and 4. Different amplifications are used in the two figures. The scintillator was fixed to the window with Canada balsam. The stilbene fluorescence spectrum does not fit the spectral sensitivity of the E. M. I. tube as good as the anthracene spectrum, but this material was chosen because it is superior in fast coincidence work.

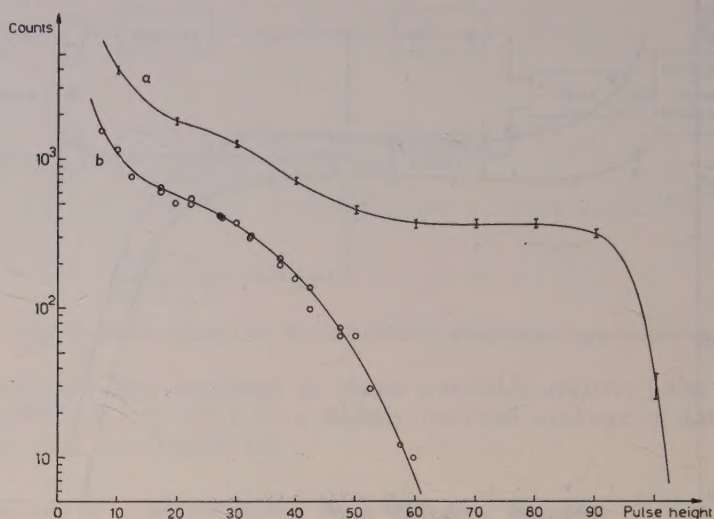


Fig. 4. Na^{22} γ -pulse spectra, 12 mm stilbene and E.M.I. 5311. *a*: original. *b*: annihilation quanta only.

Improvements

Work is now going on to increase the energy resolution for γ -rays and β -particles. The high multiplication of the E. M. I. tubes should make it possible to use a faster primary coincidence stage. We also intend to replace the A1 pulse height selector by a single channel differential discriminator.

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